EAST
12/26/03

-	283	nut near4 caulk$4	USPAT; US-PGPUB; EPO; JPO; DERWENT	2
-	827	b60g015/06.ipc. or f16f009/54.ipc.	JPO	2
-	60	(b60g015/06.ipc. or f16f009/54.ipc.) and nut	JPO	2
-	103	(280/124.155.ccls. or 280/124.147.ccls.) and nut	USPAT; US-PGPUB	2
-	13	(280/124.155.ccls. or 280/124.147.ccls.) and nut same weld$4	USPAT; US-PGPUB	2
-	3	(280/124.155.ccls. or 280/124.147.ccls.) and nut same (caulk$5 or captive or encapsulat$ or deform$5)	USPAT; US-PGPUB	2
-	139	267/$.ccls. and nut same (caulk$5 or captive or encapsulat$ or deform$5)	USPAT; US-PGPUB	2
-	0	("transverse-mounted") adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB	2
-	0	transverse adj mounted adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB	
-	0	(transverse adj mounted adj engine) same vibration adj damp$4	USPAT; US-PGPUB	
-	1	(transverse adj mounted adj engine) same vibration same damp$4	USPAT; US-PGPUB	
-	50	transverse adj mounted adj engine	USPAT; US-PGPUB	
-	0	transvers$5 adj mounted adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB	
-	2	transvers$5 adj mounted adj engine same mount same vibration adj damp$4	USPAT; US-PGPUB	
-	1	("6530587").PN.	USPAT; US-PGPUB	
-	0	6530587.URPN.	USPAT	
-	11	("0191536" | "1898721" | "2471135" | "3181641" | "3197190" | "3806151" | "4313618" | "4458918" | "4779894" | "4854606" | "6189904").PN.	USPAT	
-	1	6616159.pn.	USPAT; US-PGPUB	
-	4328	lawson.in. or deadrick.in.	USPAT; US-PGPUB; EPO; JPO; DERWENT	
-	2371	visteon.asn.	USPAT; US-PGPUB; EPO; JPO; DERWENT	
-	22	(lawson.in. or deadrick.in.) and visteon.asn.	USPAT; US-PGPUB; EPO; JPO; DERWENT	2
-	25002	B29C044/12.ipc. or B29C045/14.ipc. F16F001/368.ipc.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2
-	54	(B29C044/12.ipc. or B29C045/14.ipc. F16F001/368.ipc.) and leaf adj spring	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2(
-	11091	B29C039/10.ipc. or B60G011/08.ipc. or F16F001/18.ipc.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2
-	731	(B29C039/10.ipc. or B60G011/08.ipc. or F16F001/18.ipc.) and leaf adj spring	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2

L Number	Hits	Search Text	DB	
3	2	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.) and bladder	USPAT; US-PGPUB	
5	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
6	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
7	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
8	1	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.) same transverse.clm. adj leaf.clm.	USPAT; US-PGPUB	
4	114	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.)	USPAT; US-PGPUB	
9	80	(method or process) adj5 (leaf adj2 spring) same form	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
10	60	(method or process) adj5 (leaf adj2 spring) same mold$4	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
11	12	(US-6660114-$ or US-6461455-$ or US-6422540-$ or US-6361032-$ or US-5043117-$ or US-4894108-$ or US-4747898-$ or US-4707317-$ or US-4659071-$ or US-4420450-$).did. or (US-20020096249-$ or US-20020153689-$).did.	USPAT; US-PGPUB	
12	18	(method or process) adj5 (leaf adj2 spring) same mold$4 same cur$4	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
13	10	(method or process) adj5 (leaf adj2 spring) same mold$4 same cur$4 same (fiber$6 or fibre$5)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	
14	27	(method or process) adj5 (leaf adj2 spring) same (fiber$6 or fibre$5) same resin$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2
15	1	(method or process) adj5 (leaf adj2 spring) same (fiber$6 or fibre$5) same resin$6 same (hollow or tub$6)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2(
16	1	1992-142610.NRAN.	DERWENT	2
17	343	(leaf adj2 spring) same (fiber$6 or fibre$5) same resin$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2
18	139	(leaf adj2 spring) same (fibers! or fibres!) same resin$6	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB	2

19	3479	267/36.1-52.ccls. or 267/148-149.ccls.	USPAT; US-PGPUB
20	124	(267/36.1-52.ccls. or 267/148-149.ccls.) and resin$6 same fib$5	USPAT; US-PGPUB
21	0	6460838.URPN.	USPAT
22	7	("4530490" | "4556204" | "4565356" | "4659071" | "4696459" | "4707317" | "4969633").PN.	USPAT
23	8	(267/36.1-52.ccls. or 267/148-149.ccls.) and resin$6 same fib$5 same taper$4	USPAT; US-PGPUB
24	11	resin$6 same fib$5 same taper$4 same leaf adj2 spring	USPAT; US-PGPUB
26	64	(resin$6 same fib$5 same leaf adj2 spring) not ((leaf adj2 spring) same (fibers! or fibres!) same resin$6)	USPAT; US-PGPUB
27	73	((leaf adj2 spring) same (fibers! or fibres!) same resin$6) not (resin$6 same fib$5 same leaf adj2 spring)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
25	130	resin$6 same fib$5 same leaf adj2 spring	USPAT; US-PGPUB
28	11	(leaf adj2 spring) same (fibers! or fibres!) same resin$6 same (hollow or tub$6)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
29	41	EBATA.in. and SAITO.in.	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
30	14	EBATA.in. and SAITO.in. and leaf adj spring	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
31	2	EBATA.in. and SAITO.in. and leaf adj spring same hollow	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
32	7	((leaf adj2 spring) same (fibers! or fibres!) same resin$6) not (resin$6 same fib$5 same leaf adj2 spring) and mold$4	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
33	32	(leaf adj2 spring) same (fibers! or fibres!) same resin$6 same mold$4	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
34	9	(leaf adj2 spring) same (fibers! or fibres!) same resin$6 same mold$4 and (longitud$6 or elongated) near4 (fibers! or fibres!)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
35	25	(leaf adj2 spring) same (fibers! or fibres!) same resin$6 same (longitud$6 or elongated) near4 (fibers! or fibres!)	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB
36	1	2000-273563.NRAN.	DERWENT
37	1	1983-A1111K.NRAN.	DERWENT
38	1	1982-83998E.NRAN.	DERWENT
39	10	(US-5425829-$ or US-5118373-$ or US-5098510-$ or US-4969633-$ or US-4565356-$ or US-4530490-$ or US-6189904-$ or US-4546958-$).did. or (JP-55086935-$ or JP-60116933-$).did.	USPAT; JPC

-	10	kawada.in. and tadano.in.	USPAT; US-PGPUE EPO; JPO; DERWENT
-	4	(("5088704") or ("5064176") or ("5040775") or ("5024461")).PN.	USPAT; US-PGPUE
-	11	(("5263694") or ("4425065") or ("3878598") or ("3845860") or ("3809139") or ("3736969") or ("2722259") or ("2649884") or ("2138409") or ("1759339") or ("1705463")).PN.	USPAT; US-PGPUE
-	15	(US-5088704-$ or US-5064176-$ or US-5040775-$ or US-5024461-$ or US-5263694-$ or US-4425065-$ or US-3878598-$ or US-3845860-$ or US-3809139-$ or US-3736969-$ or US-2722259-$ or US-2649884-$ or US-2138409-$ or US-1759339-$ or US-1705463-$).did.	USPAT
-	0	("0036198").PN.	JPO
-	0	(b60g015/06.ipc. or f16f009/54.ipc.).CCLS.	JPO
-	788	b60g015/06.ipc. or f16f009/54.ipc.	JPO
-	274	280/124.155.ccls. or 280/124.147.ccls.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	106	(280/124.155.ccls. or 280/124.147.ccls.) and nut	USPAT; US-PGPUB EPO; JPO; DERWENT
-	168	(280/124.155.ccls. or 280/124.147.ccls.) not ((280/124.155.ccls. or 280/124.147.ccls.) and nut)	USPAT; US-PGPUB EPO; JPO; DERWENT
-	1	6412798.URPN.	USPAT
-	11	("4274655" | "RE31184" | "4462608" | "4497523" | "4531759" | "4618127" | "4721325" | "5064176" | "5211380" | "5308104" | "5454585").PN.	USPAT
-	2717	ikoma.in.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	49	ikoma.in. and kayaba.asn.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	6340	yoshiyuki.in.	USPAT; US-PGPUB
-	17	yoshiyuki.in. and kodama.in.	USPAT; US-PGPUB
-	18	(irie.in. or yoshiyuki.in.) and (yosie.in. or kodama.in.)	USPAT; US-PGPUB
-	141	(irie.in. or yoshiyuki.in.) and (hayashi.in. or tsuneo.in.)	USPAT; US-PGPUB
-	4	((irie.in. or yoshiyuki.in.) and (hayashi.in. or tsuneo.in.)) and (akio.in. or morioka.in.)	USPAT; US-PGPUB
-	57	188/321.11.ccls. and nut	USPAT; US-PGPUB; EPO; JPO; DERWENT
-	158	267/220-221,292-294.ccls. and nut same (rubber or elastom$6)	USPAT; US-PGPUB; EPO; JPO; DERWENT
-	333	267/220-221,292-294.ccls. and nut	USPAT; US-PGPUB; EPO; JPO; DERWENT
-	137	((267/141.4) or (267/141.5)).CCLS.	USPAT; US-PGPUB

-	27	267/220-221,292-294.ccls. and nut same groove$4	USPAT; US-PGPUB EPO; JPO; DERWENT
-	0	267/220-221,292-294.ccls. and nut same captive	USPAT; US-PGPUB EPO; JPO; DERWENT
-	2	267/220-221,292-294.ccls. and nut same caulk$4	USPAT; US-PGPUB EPO; JPO; DERWENT
-	132	267/220-221,292-294.ccls. and nut same (plate or piece)	USPAT; US-PGPUB EPO; JPO; DERWENT
-	233	saenz.in.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	3	saenz.in. and cano.in.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	1	2003-555702.NRAN.	DERWENT
-	346	(267/221).CCLS.	USPAT; US-PGPUB
-	12	kawada.in. and tadano.in.	USPAT; US-PGPUB EPO; JPO; DERWENT
-	283	nut near4 caulk$4	USPAT; US-PGPUB EPO; JPO; DERWENT
-	827	b60g015/06.ipc. or f16f009/54.ipc.	JPO
-	60	(b60g015/06.ipc. or f16f009/54.ipc.) and nut	JPO
-	103	(280/124.155.ccls. or 280/124.147.ccls.) and nut	USPAT; US-PGPUB
-	13	(280/124.155.ccls. or 280/124.147.ccls.) and nut same weld$4	USPAT; US-PGPUB
-	3	(280/124.155.ccls. or 280/124.147.ccls.) and nut same (caulk$5 or captive or encapsulat$ or deform$5)	USPAT; US-PGPUB
-	139	267/$.ccls. and nut same (caulk$5 or captive or encapsulat$ or deform$5)	USPAT; US-PGPUB
-	0	("transverse-mounted") adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB
-	0	transverse adj mounted adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB
-	0	(transverse adj mounted adj engine) same vibration adj damp$4	USPAT; US-PGPUB
-	1	(transverse adj mounted adj engine) same vibration same damp$4	USPAT; US-PGPUB
-	50	transverse adj mounted adj engine	USPAT; US-PGPUB
-	0	transvers$5 adj mounted adj engine same transmission same transmission adj mount same vibration adj damping	USPAT; US-PGPUB
-	2	transvers$5 adj mounted adj engine same mount same vibration adj damp$4	USPAT; US-PGPUB
-	1	("6530587").PN.	USPAT; US-PGPUB
-	0	6530587.URPN.	USPAT
-	11	("0191536" | "1898721" | "2471135" | "3181641" | "3197190" | "3806151" | "4313618" | "4458918" | "4779894" | "4854606" | "6189904").PN.	USPAT
-	1	6616159.pn.	USPAT; US-PGPUB

-	4328	lawson.in. or deadrick.in.	USPAT; US-PGPUE EPO; JPO; DERWENT
-	2371	visteon.asn.	USPAT; US-PGPUE EPO; JPO; DERWENT
-	22	(lawson.in. or deadrick.in.) and visteon.asn.	USPAT; US-PGPUE EPO; JPO; DERWENT
-	25002	B29C044/12.ipc. or B29C045/14.ipc. F16F001/368.ipc.	USPAT; US-PGPUE EPO; JPO; DERWENT IBM_TDB
-	54	(B29C044/12.ipc. or B29C045/14.ipc. F16F001/368.ipc.) and leaf adj spring	USPAT; US-PGPUB EPO; JPO; DERWENT IBM_TDB
-	11091	B29C039/10.ipc. or B60G011/08.ipc. or F16F001/18.ipc.	USPAT; US-PGPUB EPO; JPO; DERWENT IBM_TDB
-	731	(B29C039/10.ipc. or B60G011/08.ipc. or F16F001/18.ipc.) and leaf adj spring	USPAT; US-PGPUB EPO; JPO; DERWENT IBM_TDB
-	43	(B29C039/10.ipc. or B60G011/08.ipc. or F16F001/18.ipc.) and leaf adj spring same mold$4	USPAT; US-PGPUB EPO; JPO; DERWENT IBM_TDB
-	1	2003-228100.NRAN.	DERWENT
-	40415	B29C039/10.ipc. B29C044/12.ipc. B29C045/14.ipc. B29C070/42.ipc. B29C070/44.ipc. B29K105:08.ipc. B29L031/30.ipc. B60G011/02.ipc. B60G011/08.ipc. F16F001/18.ipc. F16F001/368.ipc.	USPAT; US-PGPUB EPO; JPO; DERWENT; IBM_TDB
-	988	(B29C039/10.ipc. B29C044/12.ipc. B29C045/14.ipc. B29C070/42.ipc. B29C070/44.ipc. B29K105:08.ipc. B29L031/30.ipc. B60G011/02.ipc. B60G011/08.ipc. F16F001/18.ipc. F16F001/368.ipc.) and leaf adj spring	USPAT; US-PGPUB EPO; JPO; DERWENT; IBM_TDB
-	8	(B29C039/10.ipc. B29C044/12.ipc. B29C045/14.ipc. B29C070/42.ipc. B29C070/44.ipc. B29K105:08.ipc. B29L031/30.ipc. B60G011/02.ipc. B60G011/08.ipc. F16F001/18.ipc. F16F001/368.ipc.) and leaf adj spring same (fiberglas or fibreglas or fiberglass or fibreglass) same resin$5	USPAT; US-PGPUB EPO; JPO; DERWENT; IBM_TDB
-	10	(US-6616159-$ or US-6460838-$ or US-6361032-$ or US-4969633-$ or US-4786033-$ or US-4659071-$).did. or (US-20030122293-$ or US-20020153648-$).did. or (GB-2375502-$ or DE-10211582-$ or JP-2003039453-$).did.	USPAT; US-PGPUB; EPO
-	8	(B29C039/10.ipc. B29C044/12.ipc. B29C045/14.ipc. B29C070/42.ipc. B29C070/44.ipc. B29K105:08.ipc. B29L031/30.ipc. B60G011/02.ipc. B60G011/08.ipc. F16F001/18.ipc. F16F001/368.ipc.) and leaf adj spring same (fiberglas or fibreglas or fiberglass or fibreglass) same resin$5	USPAT; US-PGPUB; EPO; JPO; DERWENT; IBM_TDB

-	2	"20020153648"	USPAT; US-PGP EPO; JP DERWE IBM_TDI
-	213	transverse adj leaf adj spring	USPAT; US-PGP EPO; JP DERWE
-	64	(transverse adj leaf adj spring) and (method or process)	USPAT; US-PGP EPO; JP DERWE
-	17	(transverse adj leaf adj spring) and (method.clm. or process.clm.)	USPAT; US-PGP EPO; JP DERWE
-	114	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.)	USPAT; US-PGP
-	2	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.) and inflatable same bladder	USPAT; US-PGP

L Number	Hits	Search Text	DB
3	2	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.) and bladder	USPAT; US-PGPL
5	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPL EPO; JPC DERWEN IBM_TDB
6	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPL EPO; JPC DERWEN IBM_TDB
7	676	(method or process) adj5 (leaf adj2 spring)	USPAT; US-PGPL EPO; JPC DERWEN IBM_TDB
8	1	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.) same transverse.clm. adj leaf.clm.	USPAT; US-PGPL
4	114	(method.clm. or process.clm.) adj5 (leaf.clm. adj2 spring.clm.)	USPAT; US-PGPL
9	80	(method or process) adj5 (leaf adj2 spring) same form	USPAT; US-PGPL EPO; JPC DERWEN IBM_TDB
10	60	(method or process) adj5 (leaf adj2 spring) same mold$4	USPAT; US-PGPL EPO; JPC DERWEN IBM_TDB
11	12	(US-6660114-$ or US-6461455-$ or US-6422540-$ or US-6361032-$ or US-5043117-$ or US-4894108-$ or US-4747898-$ or US-4707317-$ or US-4659071-$ or US-4420450-$).did. or (US-20020096249-$ or US-20020153689-$).did.	USPAT; US-PGPL
-	10	kawada.in. and tadano.in.	USPAT; US-PGPL EPO; JPC DERWEN
-	4	(("5088704") or ("5064176") or ("5040775") or ("5024461")).PN.	USPAT; US-PGPL
-	11	(("5263694") or ("4425065") or ("3878598") or ("3845860") or ("3809139") or ("3736969") or ("2722259") or ("2649884") or ("2138409") or ("1759339") or ("1705463")).PN.	USPAT; US-PGPL
-	15	(US-5088704-$ or US-5064176-$ or US-5040775-$ or US-5024461-$ or US-5263694-$ or US-4425065-$ or US-3878598-$ or US-3845860-$ or US-3809139-$ or US-3736969-$ or US-2722259-$ or US-2649884-$ or US-2138409-$ or US-1759339-$ or US-1705463-$).did.	USPAT
-	0	("0036198").PN.	JPO
-	0	(b60g015/06.ipc. or f16f009/54.ipc.).CCLS.	JPO
-	788	b60g015/06.ipc. or f16f009/54.ipc.	JPO
-	274	280/124.155.ccls. or 280/124.147.ccls.	USPAT; US-PGPL EPO; JPC DERWEN
-	106	(280/124.155.ccls. or 280/124.147.ccls.) and nut	USPAT; US-PGPL EPO; JPC DERWEN
-	168	(280/124.155.ccls. or 280/124.147.ccls.) not ((280/124.155.ccls. or 280/124.147.ccls.) and nut)	USPAT; US-PGPL EPO; JPC DERWEN
-	1	6412798.URPN.	USPAT

-	11	("4274655" | "RE31184" | "4462608" | "4497523" | "4531759" | "4618127" | "4721325" | "5064176" | "5211380" | "5308104" | "5454585").PN.	USPAT
-	2717	ikoma.in.	USPAT; US-PGPU EPO; JPO DERWEN
-	49	ikoma.in. and kayaba.asn.	USPAT; US-PGPU EPO; JPO DERWEN
-	6340	yoshiyuki.in.	USPAT; US-PGPU
-	17	yoshiyuki.in. and kodama.in.	USPAT; US-PGPU
-	18	(irie.in. or yoshiyuki.in.) and (yosie.in. or kodama.in.)	USPAT; US-PGPU
-	141	(irie.in. or yoshiyuki.in.) and (hayashi.in. or tsuneo.in.)	USPAT; US-PGPU
-	4	((irie.in. or yoshiyuki.in.) and (hayashi.in. or tsuneo.in.)) and (akio.in. or morioka.in.)	USPAT; US-PGPU
-	57	188/321.11.ccls. and nut	USPAT; US-PGPU EPO; JPO DERWEN
-	158	267/220-221,292-294.ccls. and nut same (rubber or elastom$6)	USPAT; US-PGPU EPO; JPO DERWEN
-	333	267/220-221,292-294.ccls. and nut	USPAT; US-PGPU EPO; JPO DERWEN
-	137	((267/141.4) or (267/141.5)).CCLS.	USPAT; US-PGPU
-	27	267/220-221,292-294.ccls. and nut same groove$4	USPAT; US-PGPU EPO; JPO DERWEN
-	0	267/220-221,292-294.ccls. and nut same captive	USPAT; US-PGPU EPO; JPO DERWEN
-	2	267/220-221,292-294.ccls. and nut same caulk$4	USPAT; US-PGPU EPO; JPO DERWEN
-	132	267/220-221,292-294.ccls. and nut same (plate or piece)	USPAT; US-PGPU EPO; JPO DERWEN
-	233	saenz.in.	USPAT; US-PGPU EPO; JPO DERWEN
-	3	saenz.in. and cano.in.	USPAT; US-PGPU EPO; JPO DERWEN
-	1	2003-555702.NRAN.	DERWEN
-	346	(267/221).CCLS.	USPAT; US-PGPU
-	12	kawada.in. and tadano.in.	USPAT; US-PGPU EPO; JPO DERWEN

Search History

US006530587B2

(12) **United States Patent**
Lawson et al.

(10) **Patent No.: US 6,530,587 B2**
(45) **Date of Patent: Mar. 11, 2003**

(54) **WHEEL SUSPENSION SYSTEM HAVING AN INTEGRATED LINK, SPRING, AND ANTI-ROLL BAR**

(75) Inventors: **Robert Christian Lawson**, Ann Arbor, MI (US); **Frederick Mark Deadrick**, Beverly Hills, MI (US)

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(52) **U.S. Cl.** **280/124.17**; 280/124.171; 267/52

(58) **Field of Search** 280/127.17, 124.171, 280/124.175, 124.134, 124.148, 124.153; 267/40, 52, 260, 47

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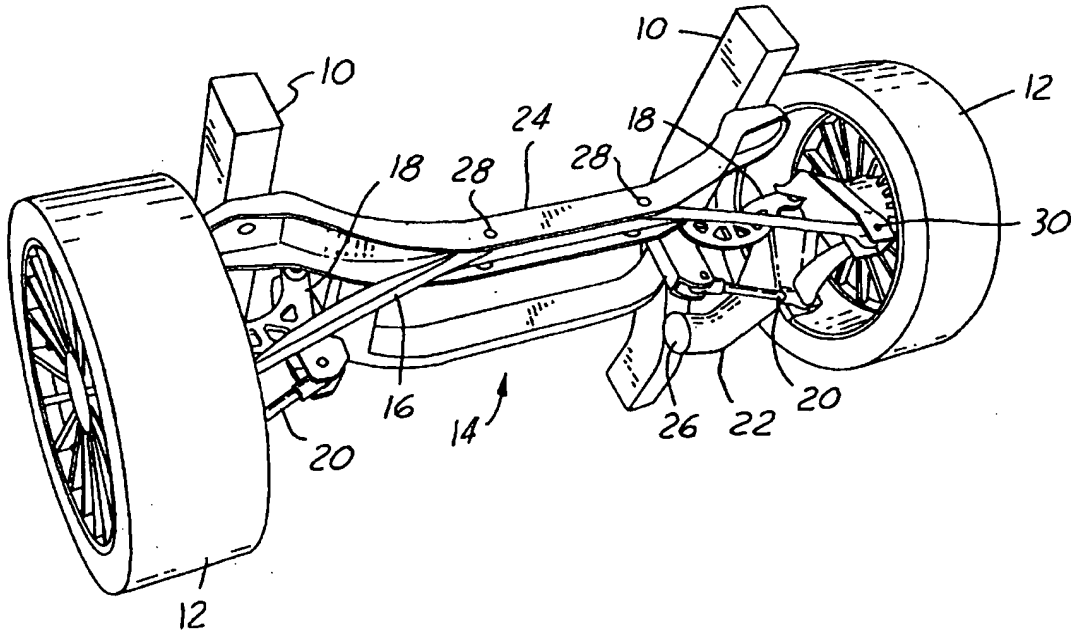
(57) **ABSTRACT**

A rear wheel suspension system replaces the lower control arms, coil springs, and anti-roll bar assembly in the prior art with a simple composite beam. By carefully designing the shape of the beam, the material system and the pivot locations, the ride and roll rates and camber and toe characteristics of the original prior art suspension system can be preserved.

15 Claims, 4 Drawing Sheets



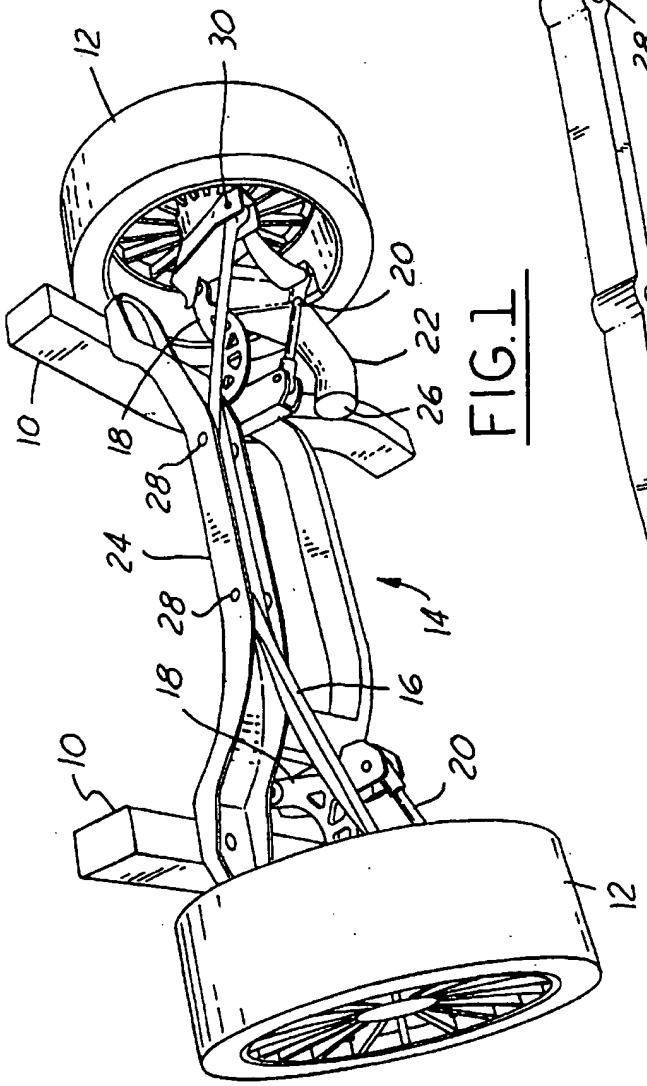


FIG.1

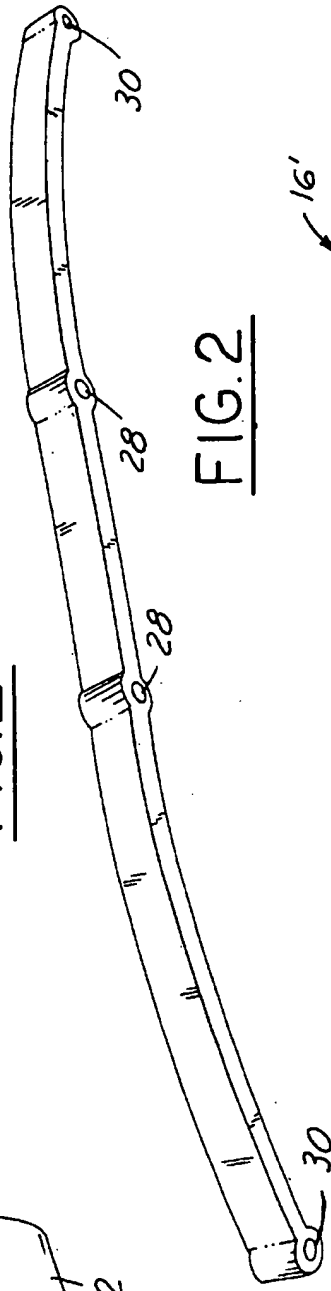


FIG.2

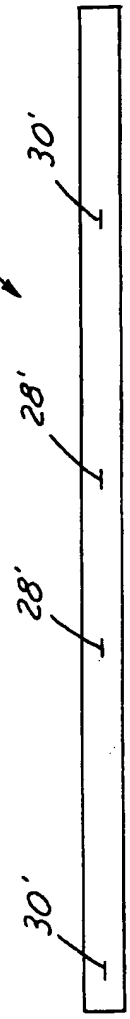


FIG.3

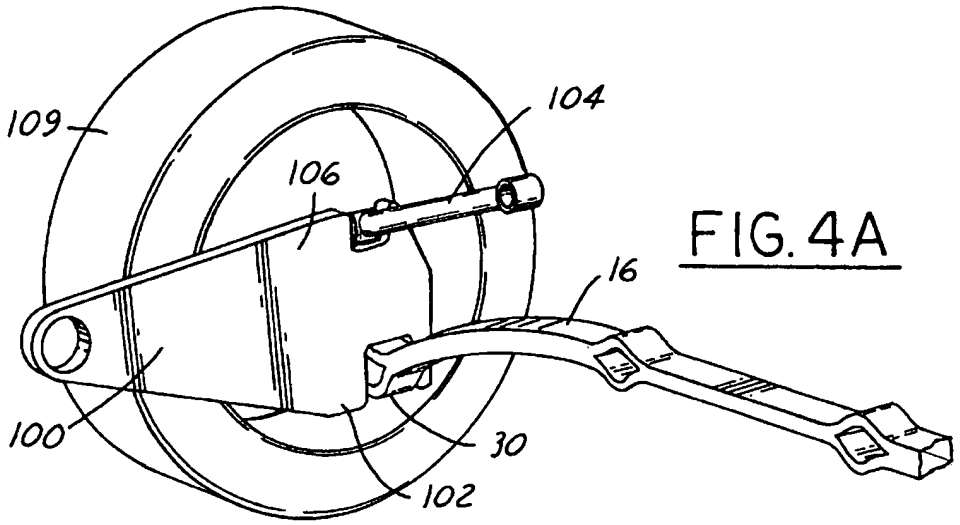


FIG. 4A

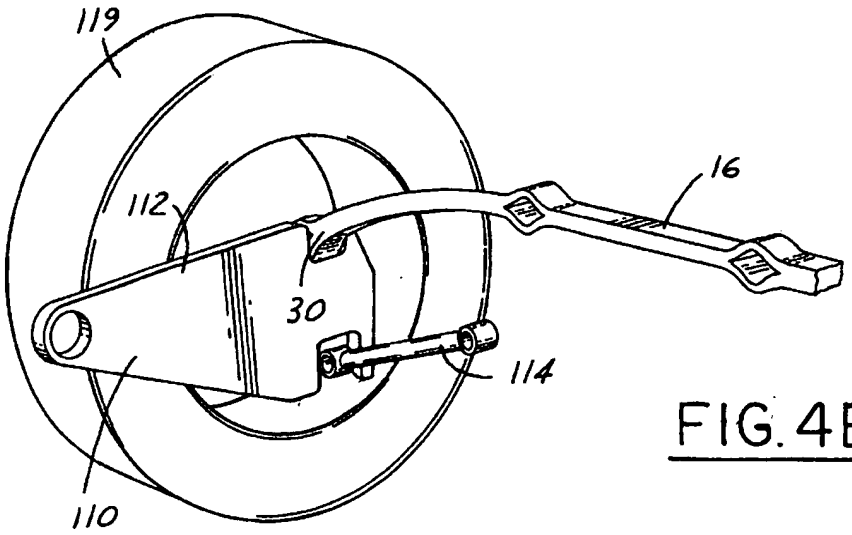


FIG. 4B

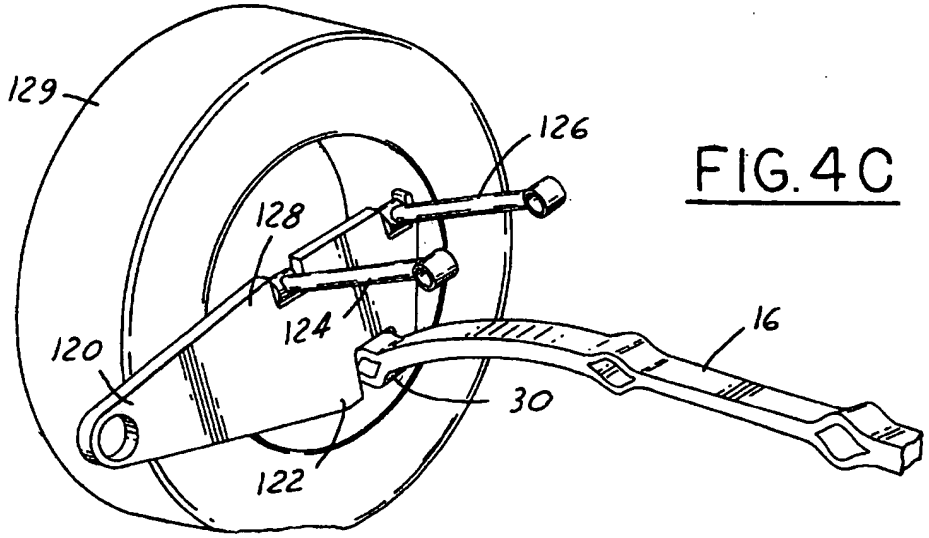


FIG. 4C

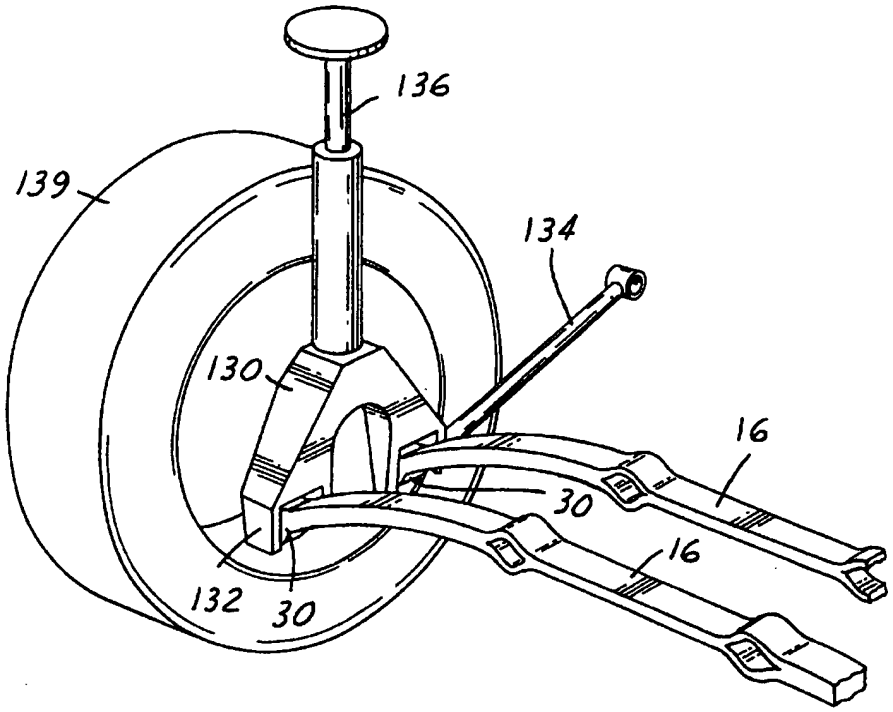


FIG. 4D

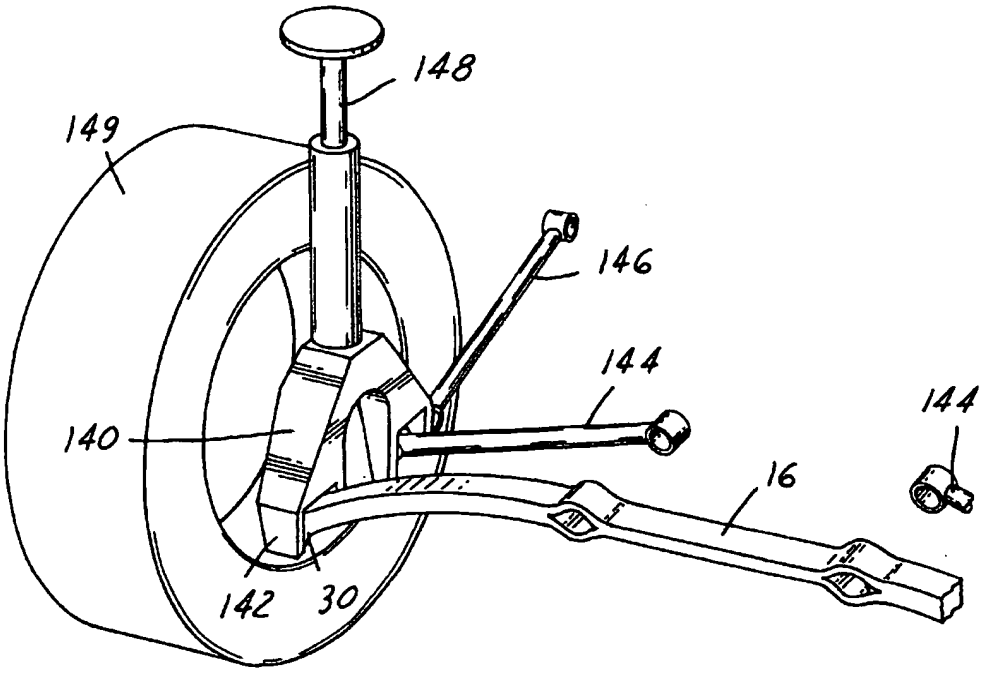


FIG. 4E

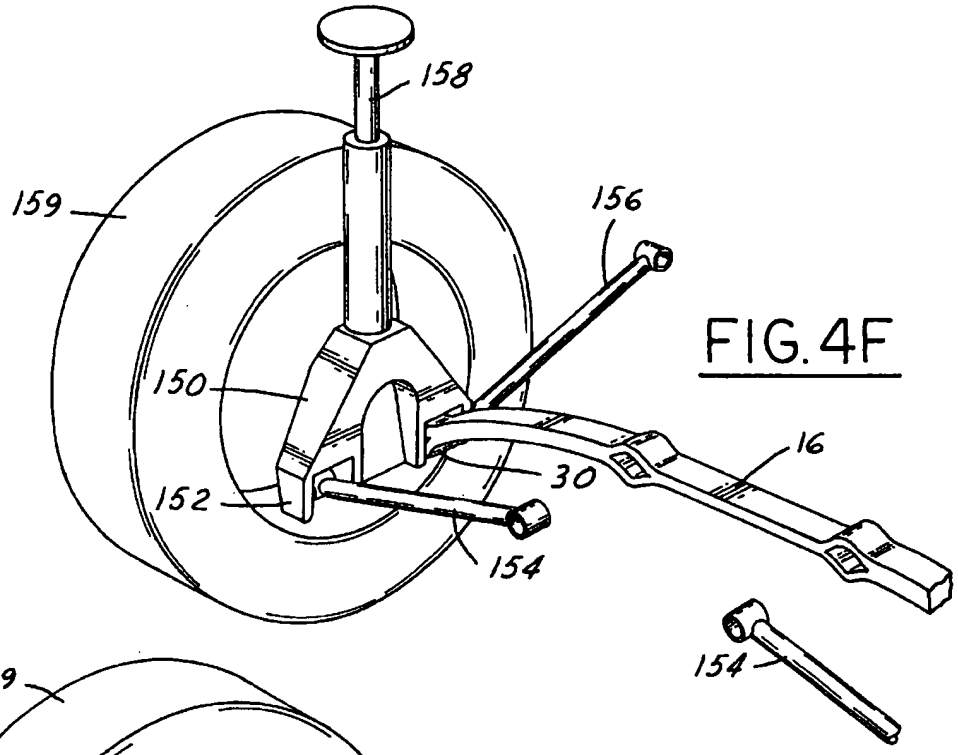

158
159
156
150
16
30
152
154
154

FIG. 4F

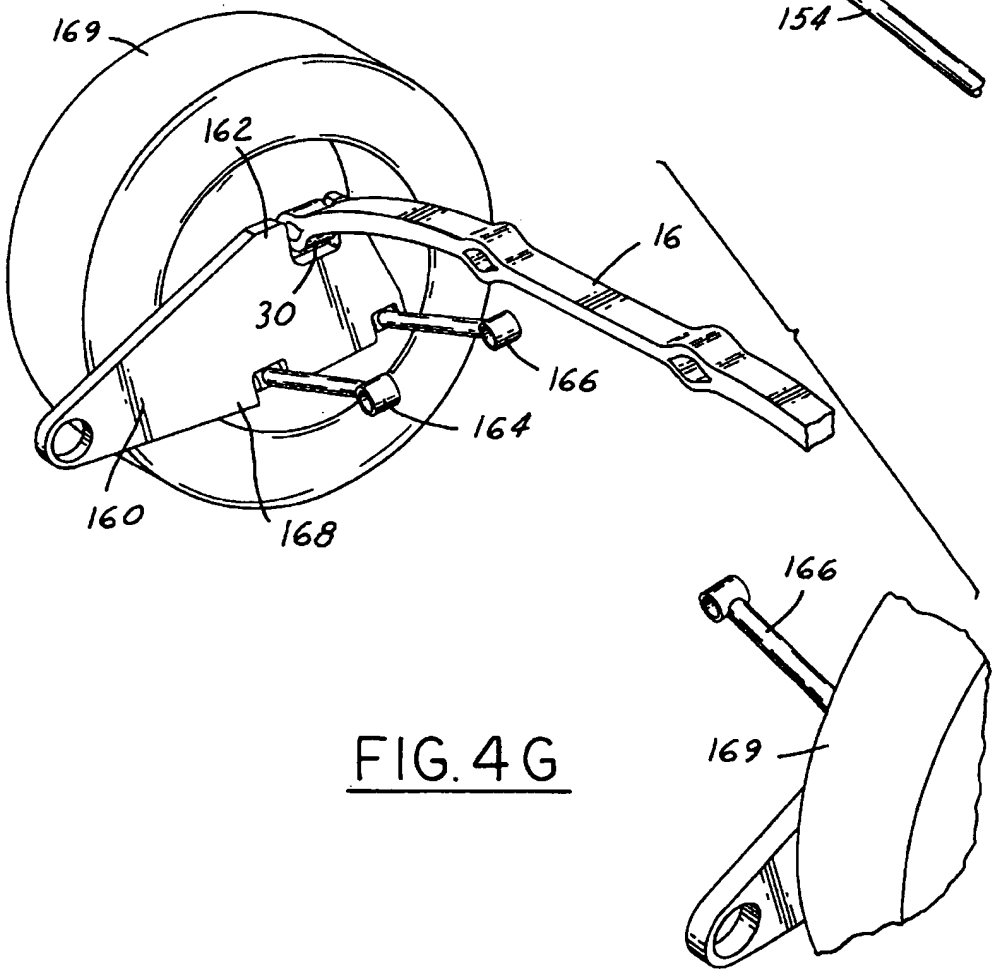

169
162
16
30
166
164
160
168
166
169

FIG. 4G

WHEEL SUSPENSION SYSTEM HAVING AN INTEGRATED LINK, SPRING, AND ANTI-ROLL BAR

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention claims priority from co-pending U.S. Provisional Application Serial No. 60/215,422, filed Jun. 30, 2000 and entitled "Method of Manufacturing Cross-Car Leaf Spring and Article Produced Thereby."

TECHNICAL FIELD

The present invention relates generally to wheel suspension systems for motor vehicles, and more particularly, to a rear wheel suspension system having an integrated link, spring, and anti-roll bar.

BACKGROUND ART

A suspension system on an automobile works with the tires, frame or unit body, wheels, wheel bearings, brake system, and steering system to provide a safe and comfortable mode of transportation. A suspension system has several important functions, including supporting the various components of an automobile, allowing the tires to move up and down to provide a comfortable ride, allowing for rapid cornering without extreme body roll, keeping the tires on the road surface, preventing excessive body squat when accelerating, preventing excessive body dive when braking, allowing the front wheels to turn side-to-side for steering, and, in combination with the steering system, keeping the wheels in correct alignment.

These suspension systems use front and rear springs to suspend a vehicle's frame, body or unitized body, engine, and powertrain above the wheels. These relatively heavy assemblies constitute what is known as "sprung" weight. The "unsprung" weight, on the other hand, includes wheels and tires, brake assemblies, and other structural members not supported by the springs. Unfortunately, high "unsprung" weight may result in adverse vehicle characteristics. Reduction of "unsprung" weight, therefore, is desirable.

Many front and rear suspension systems incorporate compression type coil springs. Some front and rear coil springs are mounted between a lower control arm and spring housing or seat in the vehicle frame or body. Coil springs are made of steel or steel alloy and may have evenly or variably spaced coils to provide adequate durability and vehicle stability under all intended load conditions. Unfortunately, compression type coil springs are typically heavy and may require significant packaging space within the vehicle.

When coil springs are used in either a front or rear suspension, three or four linkages are typically placed between the wheel axles and the frame to carry driving and braking torque. These linkages support driving and braking torque, the vertical load due to road loads, and cornering (lateral) loads. The lower control arms pivot in the frame members and sometimes support the rear coil springs to provide for up and down movement of the axle and wheel assembly. Unfortunately, these linkages increase the amount of "unsprung" weight, while increasing overall part count and complexity.

In addition, an anti-roll bar is usually attached from the rear suspension lower control arm to the frame side rail to hold the rear axle housing in proper alignment with the frame and to prevent side sway (roll motion) of the body.

Unfortunately, anti-roll bars are typically heavy and require significant packaging within the vehicle. In addition, anti-roll bars increase the overall part count and complexity of suspension systems.

The disadvantages associated with these conventional rear suspension techniques have made it apparent that a new technique for rear suspension is needed. The new technique should integrate multiple automotive suspension functions into one integral unit. Additionally, the new technique should reduce part count and weight while potentially improving noise vibration and harshness (NVH) and reducing complexity. The present invention is directed to these ends.

SUMMARY OF THE INVENTION

It is, therefore, an object of the invention to provide an improved and reliable rear wheel suspension system having an integrated link, spring, and anti-roll bar. Another object of the invention is to reduce part count and weight while improving NVH and reducing complexity and cost.

In accordance with the objects of this invention, a rear wheel suspension system having an integrated link, spring, and anti-roll bar is provided. In one embodiment of the invention, a rear wheel suspension system replaces the lower control arms, coil springs, and anti-roll bar assembly in the prior art with a simple composite beam. By designing the shape of the beam, the material system and the pivot locations, the ride and roll rates and camber and toe characteristics of the original prior art suspension system can be preserved.

The present invention thus achieves an improved rear wheel suspension system having an integrated link, spring, and anti-roll bar. The present invention is advantageous in that it integrates multiple automotive suspension functions into one unit.

Additional advantages and features of the present invention will become apparent from the description that follows, and may be realized by members of the instrumentalities and combinations particularly pointed out in the appended claims, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be well understood, there will now be described some embodiments thereof, given by way of example, reference being made to the accompanying drawings, in which:

FIG. **1** is an illustration of a rear wheel suspension system having an integrated link, spring, and anti-roll bar in accordance with one embodiment of the present invention;

FIG. **2** is an illustration of a composite beam in accordance with one embodiment of the present invention;

FIG. **3** is a cross section of a 3D woven preform part for a composite beam in accordance with a preferred embodiment of the present invention; and

FIGS. **4A–G** are illustrations of alternative preferred ways of locating the composite beam on a trailing arm within a rear wheel suspension system.

BEST MODES FOR CARRYING OUT THE INVENTION

In the following figures, the same reference numerals will be used to identify identical components in the various views. The present invention is illustrated with respect to a

rear wheel suspension system having an integrated link, spring, and anti-roll bar, particularly suited for the automotive field. However, the present invention is applicable to various other uses that may require rear wheel suspension systems.

Referring to FIG. **1**, a rear wheel suspension system **14** having an integrated link, spring, and anti-roll bar in accordance with one embodiment of the present invention is illustrated. A motor vehicle chassis **10** (or unitized body and chassis) is supported on left and right road wheels **12** by a wheel suspension system **14**. The wheel suspension system **14** includes a composite beam **16**, a pair of upper control arms **18**, and a pair of lower toe links **20**.

The composite beam **16** replaces the lower control arms, coil springs, and anti-roll bar assembly in the prior art rear wheel suspension system. The composite beam **16** is preferably composed of a fiber-reinforced thermoset or thermoplastic polymer laminate material. Preferably, the polymer used in the composite laminate layers is an epoxy resin. The method for making the composite beam **16** is described below in FIG. **3**.

Each upper control arm **18** and lower toe link **20** connects a flexible trailing arm **22**, or knuckle, to the motor vehicle chassis **10** through a chassis cross-member **24**. Members are provided to pivotally connect the forward end **26** of each trailing arm **22** to the chassis **10**. Additional members are provided to pivotally connect the inner ends of each upper control arm **18** and lower toe link **20** to the chassis cross-member **24** and their outer ends to a respective trailing arm **22**.

As best seen in FIG. **2**, inner attachment members **28** are provided to pivotally connect the composite beam **16** to the chassis cross-member **24**. Also, outer attachment members **30** are provided at each end of composite beam **16** to pivotally connect the chassis cross-member **24** to a respective trailing arm **22**.

Referring to FIG. **3**, a cross section of a 3D woven preform part **16'** for a composite beam **16** in accordance with one embodiment of the present invention is illustrated. In this process, multiple spools of fiber (glass and/or carbon) feed fiber into a weaving machine that loops the fiber across the width and through the thickness, with a majority of the fibers running along the length of the composite beam preform. A curable resin, preferably an epoxy resin, is added to the weaving to bind the fibers into a preform. The initial preform would be approximately 1.5 m wide and may be manufactured using a 3D textile weaving process. Approximately 50 mm of the initial preform would be cut off for each part **16'**. Sacrificial inserts would be placed into the preform slits, corresponding to an outer pivot **30'** and inner pivot **28'**, thereby expanding them into holes that are used to form attachment members **30** and **28**, respectively. This preform **16'** could then be placed in a mold and consolidated with resin using a resin transfer molding (RTM) or vacuum-assisted resin transfer molding (VARTM) process to form the finished composite beam **16**.

In an alternative fabrication method, the initial preform **16'** could be cut very wide (500–1000 mm wide. After the wide piece is molded and cured, the preform is cut into 50 mm pieces using a saw or waterjet or similar type device. This method may be preferable in that it is easier to cut the preform **16'** after curing and because it is more efficient to load one large preform into a mold as compared with multiple smaller preforms into multiple molds.

The composite beam **16** may also be made using other composite manufacturing techniques. These techniques may include the use of fiber pre-impregnated with resin, dry fibers consolidated using either the RTM or VARTM process, filament winding, textile braiding, or other composite manufacturing techniques known in the art.

The present invention allows the trailing arm **22** to locate the wheel axis fore/aft and react to braking torque, while the three lateral links (provided by composite beam **16**, upper control arm **18**, and lower toe link **20**) provide camber and toe control. Due to the present suspension design, the wheel axis moves along an arc as viewed in the side view. The outer attachment members **30** on the composite beam **16** must also follow an arc. The composite beam **16** must flex both vertically and fore/aft. The outer attachment member **30** is free to flex in the Y direction, and in doing so it controls the toe along with the upper control arm **18**. To reduce stresses and forces in the member **16** due to the fore/aft bending of the member **16** as the outer attachment member **30** follows the arc, the concept of using a composite beam **16** with a cross section whose bending axis is angled in the XZ plane may be used. This results in a composite beam **16** that travels fore/aft as well as vertically when loaded with only a vertical load at the outer attachment member **30**. The composite beam **16** may be designed to have a trapezoidal cross section to lower stresses.

By carefully designing the shape of the composite beam **16**, the material system and the pivot locations **28**, the ride and roll rates and camber and toe characteristics of the rear wheel suspension system **14** can be changed to achieve desired characteristics. For example, by varying the bending stiffness at various points along the composite beam **16**, the ride and roll characteristics of the rear wheel suspension system **14** may be altered.

While the composite beam **16** present invention is preferably coupled to the trailing arm **22** as in FIG. **1**, there are many other ways of locating the composite beam **16** onto the trailing arm **22**. Some of these preferred ways are depicted below in FIGS. **4A–4G**.

The descriptions below in FIGS. **4A–4G** refer to two different types of trailing arms; semi-rigid and flexible. In flexible trailing arms, the region of the trailing arm connecting the lateral links, composite beam **16**, and the axle are fairly rigid. Meanwhile the forward portion of the trailing arm is relatively flexible, having a thin (Y direction) yet tall (Z direction) cross section. This yields a suspension system where toe and camber are controlled by the lateral links and cross car spring(s), while the forward portion of the trailing arm reacts the braking torque and provides fore/aft location. This design allows the suspension to be better tuned to both improve handling and reduce NVH.

Semi-rigid trailing arms, on the other hand, play an integral role in controlling toe in the suspension, in addition to the functions it provides as described above with regards to flexible trailing arms. Suspension topologies including a "semi-rigid" trailing arm typically require one fewer locating members (either composite beam **16** or lateral link) per side.

Referring now to FIG. **4A**, the outer attachment members **30** of the composite beam **16** are each coupled to a respective lower portion **102** of a semi-rigid trailing arm **100**. An upper control arm **104** is also shown coupled to an upper portion **106** of the semi-rigid trailing arm **100**. Each trailing arm **100** is used for rotatably mounting a road wheel **109**.

Referring now to FIG. **4B**, the outer attachment members **30** of the composite beam **16** are coupled to a respective upper portion **112** of a semi-rigid trailing arm **110**. A lower toe link **114** is also coupled to a lower portion **116** of the

semi-rigid trailing arm **110**. Each trailing arm **110** is used for rotatably mounting a road wheel **119**.

Referring now to FIG. **4C**, the outer attachment members **30** of the composite beam **16** are coupled to a lower portion **122** of a flexible trailing arm **120**. A pair of upper control arms **124, 126** are also shown coupled to an upper portion **128** of the semi-rigid trailing arm **120**. Each trailing arm **120** is used for rotatably mounting a road wheel **129**.

Referring now to FIG. **4D**, the outer attachment members **30** of a pair of composite beams **16** are each coupled to a respective lower portion **132** of a semi-rigid trailing arm **130**. Also coupled to the semi-rigid trailing arm **130** is a fore-aft link **134** and a damper and strut **136**. Each trailing arm **130** is used for rotatably mounting a road wheel **139**.

Referring now to FIG. **4E**, the outer attachment members **30** of a composite beam **16** are coupled to a respective lower portion **142** of a semi-rigid trailing arm **140**. A lower toe link **144** is also coupled to the lower portion **142**. Also coupled to the semi-rigid trailing arm **140** is a fore-aft link **146** and a damper and strut **148**. In this embodiment, the fore-aft link **146** is located is close proximity to the lower toe link **144**. Each trailing arm **140** is used for rotatably mounting a road wheel **149**.

Referring now to FIG. **4F**, the outer attachment members **30** of a composite beam **16** are coupled to a respective lower portion **152** of a semi-rigid trailing arm **150**. A lower toe link **154** is also coupled to the lower portion **152**. Also coupled to the semi-rigid trailing arm **150** is a fore-aft link **156** and a damper and strut **158**. In this embodiment, the fore-aft link **156** is located is close proximity to the composite beam **16**. Each trailing arm **150** is used for rotatably mounting a road wheel **159**.

Referring now to FIG. **4G**, the outer attachment members **30** of the composite beam are attached to a respective upper portion **162** of a semi-rigid trailing arm **160**. A pair of lower toe links **164, 166** are also coupled to a lower portion **168** of the semi-rigid trailing arm **160**. Each trailing arm **160** is used for rotatably mounting a road wheel **169**.

While not shown in FIGS. **4A–4G**, each trailing arm **102, 110, 120, 160** or trailing arm knuckle **130, 140, 150** is attached to the vehicle chassis at its forward end in a manner similarly described in FIG. **1**, wherein the forward end **26** of the trailing arm **22** is coupled to the vehicle chassis. Also, each fore-aft link **134, 146, 156** is attached to the vehicle body or frame. Further, each upper control arm **104, 124, 126** is mounted to a vehicle chassis cross member in a manner similar to the mounting of the upper control arm **18** in FIG. **1**. Finally, each lower toe link **114, 144, 154, 166** is coupled to a chassis cross member in a manner similar to mounting the lower toe link **20** to the chassis cross-member **24** in FIG. **1**.

The present invention thus achieves an improved and reliable rear wheel suspension system having an integrated link, spring, and anti-roll bar by using a composite beam **16**. In this way, the present invention integrates multiple automotive suspension functions into one integral unit.

It is to be understood that the preceding description of the preferred embodiment is merely illustrative of some of the many specific embodiments that represent applications of the principles of the present invention. Clearly, numerous and other arrangements would be evident to those skilled in the art without departing from the scope of the invention as defined by the following claims.

What is claimed is:

1. A rear wheel suspension for a vehicle comprising:

a chassis;

a pair of trailing arms for rotatably mounting a pair of road wheels;

a chassis cross-member coupled to said chassis;

a composite beam having outer attachment members and inner attachment members, said outer attachment members rotatably coupled to each of said pair of trailing arms and said inner attachment members rotatably coupled to said chassis cross-member; and

a pair of upper control arms, each of said upper control arms having an inner control arm end and an outer control arm end, wherein said inner control arm ends are rotatably coupled to said chassis cross-member and wherein said outer control arm ends are each rotatably coupled to a respective one of said pair of trailing arms.

2. The rear wheel suspension for a vehicle as recited in claim **1**, wherein said chassis is a unitized body.

3. The rear wheel suspension for a vehicle as recited in claim **1**, wherein said chassis is a vehicle frame.

4. The rear wheel suspension for a vehicle as recited in claim **1**, further comprising a pair of lower toe links, each of said lower toe links having an inner lower link arm end and an outer toe link arm end, wherein each of said inner toe link arm ends are rotatably coupled to said chassis cross-member and wherein each of said outer toe link arm ends are rotatably coupled to a respective one of said pair of trailing arms.

5. The rear wheel suspension for a vehicle as recited in claim **1**, wherein said composite beam has a rectangular cross section.

6. The rear wheel suspension for a vehicle as recited in claim **1**, wherein said composite beam has a cross section whose bending axis is angled in the XZ plane.

7. The rear wheel suspension for a vehicle as recited in claim **1**, wherein said composite beam has a trapezoidal cross section.

8. The rear wheel suspension for a vehicle as recited in claim **1**, wherein a location of said outer attachment members and inner attachment members on said composite beam are adjusted such that a bending trajectory of said composite beam approximately matches a target arc.

9. A rear wheel suspension for a vehicle comprising:

a chassis;

a pair of trailing arms for rotatably mounting a pair of road wheels;

a chassis cross-member coupled to said chassis; and

a composite beam having outer attachment members and inner attachment members, said outer attachment members rotatably coupled to each of said pair of trailing arms and said inner attachment members rotatably coupled to said chassis cross-member; and

a pair of lower toe links, each of said lower toe links having an inner lower link arm end and an outer toe link arm end, wherein each of said inner toe link arm ends are rotatably coupled to said chassis cross-member and wherein each of said outer toe link arm ends are rotatably coupled to a respective one of said pair of trailing arms.

10. The rear wheel suspension for a vehicle as recited in claim 9, wherein said chassis is a unitized body.

11. The rear wheel suspension for a vehicle as recited in claim 9, wherein said chassis is a vehicle frame.

12. The rear wheel suspension for a vehicle as recited in claim 9, wherein said composite beam has a rectangular cross section.

13. The rear wheel suspension for a vehicle as recited in claim 9 wherein said composite beam has a cross section whose bending axis is angled in the XZ plane.

14. The rear wheel suspension for a vehicle as recited in claim 9, wherein said composite beam has a trapezoidal cross section.

15. The rear wheel suspension for a vehicle as recited in 9, wherein a location of said outer attachment members and inner attachment members on said composite beam are adjusted such that a bending trajectory of said composite beam approximately matches a target arc.

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